theory, specifically the idea that conflict drives the emergence of a novel structural organization (Swenson 1997). Here we focus on this latter idea and suggest that conflict needs to be expanded to include not only conflict between action options, but also between action and perception.

There is a large body of research that provides evidence for a discrepancy between actual action capabilities and beliefs about such actions capabilities (e.g., Kozhevnikov & Hegarty 2001; Krist et al. 1993). The traditional explanation is that such discrepancy is due to two encapsulated systems: an action system, which guides the movements, and a judgment system, which predicts actions. Such dichotomy of structures not only runs counter to PFT, but also is overly simplistic, as illustrated in a preliminary study we carried out to investigate the ability of children to predict how far they can throw balls after feedback.

Participants were 12 children from a Midwestern daycare serving middle-income families. The children ranged in age from 4 to 10 years, half of them being younger than 72 months (M = 5.04 years), and half of them being older than 72 months (M = 7.94 years). A hallway at the daycare, approximately 16 feet long, was taped off to create an area in which to throw medicine balls. Three medicine balls that differed in heaviness were used. The heaviest medicine ball weighed 6 pounds, the middle ball weighed 4 pounds, and the lightest ball weighed 2 pounds. A yellow square at the end of the hallway acted as a place for the children to stand while throwing the different balls. The researcher prompted each child to "guess how far you can throw the ball." The child was then instructed to stop the researcher, who was walking backwards towards the end of the hallway, in order to indicate how far they thought they would be able to throw the medicine ball. After the child stopped the researcher, the distance between the researcher and the yellow square was measured and recorded. Finally, the researcher left the hallway, and the child was told to "throw the ball." As needed, the researcher reminded the child to throw underhand if the child tried to gain momentum by throwing the ball from the side. The spot where the medicine ball landed was marked, measured, and recorded. This procedure was repeated twice for a total of three trials for each of the balls.

The absolute difference between the predicted distance thrown and the actual distance thrown was determined for each throw and then averaged across trials and children. Figure 1 shows the results obtained. Although the older children were better able than preschoolers to perceive the distance they could throw a ball, there was an interaction between accuracy and ball weight. Specifically, the improvement with age was only for the lightest balls, not the medium and heaviest balls. Their ability to accurately adjust their predictions for how far they could throw the medium and heaviest balls was not statistically different from younger children. Thus, for the heavier balls, older children were no better than younger children at self-correction.

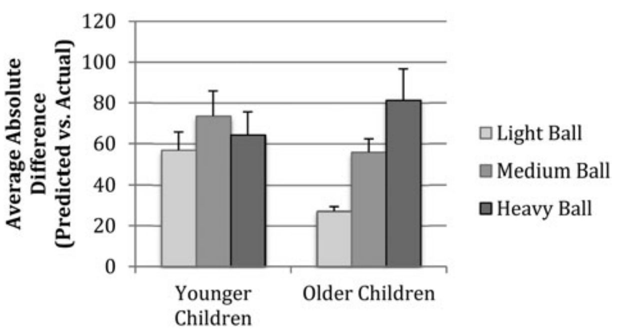

Figure 1 (Hardcastle et al.). Average absolute difference between children's predicted distance thrown and the actual distance thrown, separated by age group and ball weight. Error bars represent standard errors. Measures are in centimeters.

Our results add to the list of findings showing a discrepancy between perceived action capabilities and actual capabilities, even after feedback. Although perception and action can align after experience (e.g., Zhu & Bingham 2010), and although there can be a positive relationship between preschoolers' self-perceptions of the physical ability and fundamental motor skills (Robinson 2010), this is not always the case (cf. Kloos & Amazeen 2002). Our results show that such a discrepancy does not fit a theory of independent action and judgment systems. This is because the heaviness of the ball actually matters. To accommodate such context effects, a dichotomous model of action and perception would have to be expanded ad hoc to take into account object weight. Instead, we propose that prediction, as well as action, results from intricate interaction of idiosyncratic constraints, which differ not only as a function of the task ("predict" vs. "throw"), but also as a function of perceptual features (ball heaviness).

The PFT would suggest that older children are better at predicting their "throwability," given that they have had more experience in using conscious information to inform behavioral outputs than preschoolers. Finding that there are circumstances in which predictability does not improve with experience requires expanding PFT. It needs to incorporate not only conflict among potential actions, but also conflict between perception/judgment and action. We conclude that, while compatible with PFT, developmental studies open up the approach to new ways of investigating its tenets.

At what timescale does consciousness operate?

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Bernhard Hommel[a] and Reinout W. Wiers[b]
[a]Cognitive Psychology Unit & Leiden Institute for Brain and Cognition, Leiden University, 2333 AK Leiden, The Netherlands; [b]Department of Psychology, Addiction Development and Psychopathology (ADAPT) Lab, University of Amsterdam, 1018 XA Amsterdam, The Netherlands.
hommel@fsw.leidenuniv.nl r.wiers@uva.nl
www.bernhard-hommel.eu
http://www.uva.nl/en/contact/staff/item/r.w.h.j.wiers.html?f=wiers

Abstract: While applauding Morsella et al. for linking consciousness to action control, we ask what their theory implies regarding the exact functionality of consciousness and the timescale at which it operates. Does consciousness operate on, and resolve the conflict it emerges from (despite its slowness), or does it operate on future conflicts that it might resolve by externalizing/socializing cognitive control?

We applaud Morsella and colleagues for their original, innovative approach and welcome the uncommon, but from an evolutionary perspective very convincing, move (given that evolution operates on actions, not on thoughts) to link consciousness to action control. Many aspects of the theory invite empirical testing, which is likely to stimulate the field. However, we feel that to fully exploit its hypothesis-generating potential, the theory needs to be more specific with respect to the exact functionality that consciousness is assumed to have and to the timescale at which consciousness is thought to operate. We see two possible scenarios, which raise different questions.

The first scenario considers consciousness to operate online, that is, on the same short timescale in which the decision-making process operates. This would mean that consciousness not only emerges from/through action-selection conflict, but also operates on that same conflict. How could that work? Conflict solution requires the integration of information (including the conflicting parties and the goal the agent aims at). This fits with the integration consensus but raises the question: In which exact sense do Morsella et al. go beyond the global workspace theory of Baars (1988)? It also raises the question of *how* consciousness could influence the decision-making process involving conflict; is it not too slow to resolve conflict within the 450 msec window that typical responses in conflict tasks take, given that consciousness has been estimated to take hundreds of milliseconds to emerge (Dehaene et al. 2006)? It is this feature, together with the lack of any empirical evidence for an online role of consciousness, that led Hommel (2013) to doubt any online functionality of consciousness. Morsella et al. admit that there are "good reasons" to doubt that consciousness is involved in online action control, but they do not further address this as a problem for their own approach. Moreover, even if consciousness could emerge and operate on time, and even if it would allow for the access to distributed information that speeds up conflict solution, it is not clear why this integration function requires having a conscious experience. Why could a philosophical zombie without any conscious experience not possess such an integrative function? One case where online conscious experience appears to have a strong effect is addiction: conscious craving can overwhelm long-term considerations and lead to actions not consciously intended and later regretted (Kavanagh et al. 2005; Wiers et al. 2014). However, this effect is at a longer timescale than experiments on online action control (seconds to minutes), and its effect is negative in view of the long-term goals of the individual. Hence, a positive example of conscious action control is still wanting.

The second scenario considers consciousness as an off-line function that does not operate during the ongoing perception-action event but prepares the agent for later events of the same sort. Rather than resolving the current conflict, consciously representing, reflecting, and communicating about the conflict and/or the solution could contribute to prevent the agent from encountering the conflict again, or at least to prepare her to deal with such conflicts more efficiently in the future. It may be no coincidence that the ability to communicate about an event (i.e., conscious report) is the most widely used technique to assess conscious representations in humans. Rather than merely a methodological convenience, the ability to communicate about conscious states may actually be the essence of what consciousness has evolved to achieve (Baumeister & Bargh 2014; Baumeister & Masicampo 2010; Hommel, in press). We may thus represent action conflicts consciously because that allows us to reflect on and communicate the existence of the conflict, our ways to deal with them, and the success of doing so. This allows for social learning and strategy transmission, but also for socializing the conflict.

Several theorists have argued that this indirect social role of consciousness has permitted humans to expand the number of individuals they interact with exponentially (Baumeister & Masicampo 2010; Levitin 2014). Returning to our addiction example, by telling others about your goal to quit smoking you can mobilize them to help you when dealing with your urge to smoke the next time, this interaction serving as a reminder about your actual goals – you in essence externalize and socialize your goals and executive control functions. In treatment, you may further learn to "surf the urge" (Bowen & Marlatt 2009) and experience that the conscious urge will also descend when not acted upon. In addition, alternative strategies for weak moments are premeditated: if you often experience strong urges when stressed, it is important to prepare actions other than smoking (e.g., running, meditation, etc.) for upcoming stressful occasions, again externalizing future action control in a desirable way. Given the larger timescale of this operation mode, neither the slowness of conscious representation nor the absence of evidence for online functions of consciousness would be counter-arguments, and it would be obvious why conscious representations need to be conscious. To paraphrase Shariff et al. (2008), although we may subjectively feel that our conscious will operates like a motorboat and we are steering where we want to go, the true operation of consciousness may be more indirect, like a sailing boat, in which we can learn to influence the boat's course in indirect ways, adjusting for the wind and the currents, which will eventually get us to our intended destination.

We would like to invite Morsella and colleagues to become more specific with regard to the timescale of conscious operations and their concrete functionality. This would not only strengthen the approach's potential to stimulate empirical research, but also strongly increase its well-deserved visibility and impact.

Conflicts everywhere! Perceptions, actions, and cognition all entail memory and reflect conflict

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Jerome S. Jordan[a] and David W. Vinson[b]
[a]*Department of Psychology, Illinois State University, Normal, IL 61790-4620;*
[b]*Cognitive and Information Sciences, University of California, Merced, Merced, CA 95340.*
jsjorda@ilstu.edu dvinson@ucmerced.edu
https://about.illinoisstate.edu/jsjorda
http://davevinson.com/

Abstract: Morsella et al. assert that the function of consciousness is to determine which of many competing action options is expressed through the skeletomuscular system at any given moment. The present commentary addresses this issue from the first-person perspective and agrees with Morsella and colleagues, yet further proposes that the option-selection function of consciousness plays out in cognition as well.

As I sat to write this comment on Morsella et al.'s action-based synthesis of the science of consciousness, I found myself forced to examine the events that eventually led to my current situation. According to Morsella et al.'s passive frame theory (PFT), the contents that entered into my deliberations would be perceptual representations of external events (e.g., the computer screen in front of me, or the letters that appear on the screen as I type), as well as perceptual representations activated by unconscious corollary discharges, such as my urge to turn my head, look away from the screen, and close my eyes as I try to figure out what to write next. As I turn away, I find myself focusing on PFT's assertion that the contents of perceptual representations are encapsulated. Just then, Proffitt's (2006) economy of action (EoC) theory and Gibson's (1979) theory of direct perception enter my conscious field at roughly the same time. Suddenly, I see myself at a pub, engaged in arguments with dear friends about whether or not perception requires representations. I laugh out loud. Then I realize I have been sitting for some time, my left elbow propped on the desk, my head in my hand, my eyes closed. Eyes open, I realize that I have a co-author on this paper and have yet to include any of his material. I look for the email he sent me, copy a particularly clever section, and paste it into this comment.

My coauthor writes: "While I agree that consciousness influences skeletomotor activity, memories influence reflexive responses within the skeletomotor system as well. This challenges Morsella et al.'s commitment toward conceptualizing cognition using a modular approach. There are many studies, both neural and perceptual, that show how action-based memories are integrated into efference streams affecting planned skeletomotor action. Specifically, motor-cortical regions associated with action planning are more active when viewing dancers whose expertise is similar to one's own (Calvo-Merino et al. 2005), suggesting that the observation of another's actions activates past action plans associated with moving oneself. If so, one's perceptions should be influenced by the observation of another's actions when they elicit motor-cortical activation associated with acting. Perceived distance estimates increase when observing another carry a weighted backpack only if the observer previously carried the weighted backpack and is